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Technical Memo

To: Steve Gramm, SDDOT	
From: HDR	Project: I-190 Silver Street Study
CC:	
Date: 6/22/2010	Job No: SDDOT 410445, W.O. PD-02-09

RE: Task 200: Develop Interstate improvement options

This Technical Memo has been prepared to document the data, analysis and findings as outlined in the Task 200 section of the subject work order. The Technical Memo is organized by subtask and the data, analysis and findings related to each subtask are presented in the subtask discussions. The objective of this task is to determine needed Interstate improvements.

Subtask 201: Develop Interstate 190 mainline design concepts. No mainline design deficiencies were identified, other than the non-standard ramp locations that will be addressed in Subtask 202.

Subtask 202: Develop options for the I-190/Silver St. interchange. Diamond, single-point and parclo concepts were developed for replacement of the I-190/Silver St. interchange. Each of the concepts also included options for using the existing Silver St./North St. cross-road alignment and for using a new cross-road configuration with a more east/west alignment. Each of the concepts is discussed below and displayed in the concept drawings that accompany this technical memorandum.

- Option 1 – Full diamond interchange at Silver Street/North Street with I-190 shifted west. Shifting the I-190 alignment to the west allows for sufficient room to build all interchange options and provide adequate turn lanes and other geometric features. The southbound I-190 ramp terminal in this option suffers from a fairly high degree of skew on the cross-road and subsequent sharp turning paths on some movements. The mainline bridges would be relatively long due to the cross-road skew. Additional right-of-way will be needed west of the existing I-190, although some of the needed property is already in public ownership. Additional local street connections will be needed west of the interchange to facilitate local traffic movement. The parking lots at Central High School will no longer be allowed to access the Interstate off ramp in this concept. The ramp in the northeast quadrant may also provide limited local street access for a short distance before the actual entrance ramp begins (optional).
- Option 1a – Full diamond interchange at North Street with I-190 shifted west. This option is similar to option 1, except the cross-road has been realigned to connect to the new local street west of the interchange. The geometry of the ramp terminal intersections is improved over Option 1 and the interchange bridges would be shorter than required for the skewed cross-road in Option 1.
- Option 2 – Single point diamond interchange at Silver Street/North Street with I-190 shifted west. The single-point ramp terminal suffers from a fairly high degree of skew on the cross-road and a large area of pavement for turning movements. The mainline bridges would be relatively long and wide due to the cross-road skew. Additional right-of-way will be needed west of the existing I-190, although some of the needed property is already in public ownership. The additional right-of-way required will be less than Option 1 or Option 1a. Additional local street connections will be needed west of the interchange to facilitate local traffic movement. The parking lots at Central High School will no longer be allowed to access the Interstate off ramp in this concept.
- Option 2a – Single point diamond interchange at North Street with I-190 shifted west. This option is similar to option 2, except the cross-road has been realigned to connect to the new local street west of

the interchange. The geometry of the ramp terminal intersection is improved over Option 2, less right-of-way will be required than Option 2, and the bridge dimensions are reduced from Option 2

- Option 3 – I-190 interchange with loop at North Street. Connecting the cross-road to the new roadway west of the interchange results in the opportunity to provide a loop ramp to handle one of the largest turning volumes. Eastbound traffic would not be able to turn south at the interchange in this concept, but other local street alternatives are available. The mainline bridges would be relatively short in this option, but the southbound bridge would need to be three lanes wide to handle the accelerating loop traffic. Additional right-of-way will be needed west of the existing I-190, although some of the needed property is already in public ownership. The additional right-of-way required will be larger in the loop quadrant, but less in the southwest quadrant. Additional local street connections will be needed west of the interchange to facilitate local traffic movement. The parking lots at Central High School will no longer be allowed to access the Interstate off ramp in this concept.
- Option 3a – I-190 interchange with loop at North Street and EB to SB access. This concept is similar to Option 3, but a connection is provided for eastbound traffic to access the loop.
- Option 3b – I-190 interchange with Loop at North Street and EB to SB on-ramp. This concept is similar to Option 3, but a southbound on ramp is provided to serve eastbound traffic.
- Other options – additional options were also considered that realign I-190 to connect to Mt. Rushmore Road at Omaha Street. These options are not reproduced here because they interfere with the planned expansion of Central High School and will likely be screened by environmental considerations.

RAMP TERMINAL LEVEL OF SERVICE (Projected 2030 traffic)

	LEVEL OF SERVICE	
RAMP TERMINAL	**AM**	**PM**
DIAMOND SOUTHBOUND	C	B
DIAMOND NORTHBOUND	B	B
SINGLE POINT	A	A
LOOP SOUTHBOUND	A	A
LOOP NORTHBOUND	B	B

Subtask 203: Present and review concepts. Concepts were presented to SDDOT staff at a meeting held May 13, 2010 in Pierre. Meeting notes were prepared addressing the comments (attached) and the options were finalized for inclusion in this technical memo.

ATTACHMENTS

Option concept drawings

Meeting notes

Synchro output

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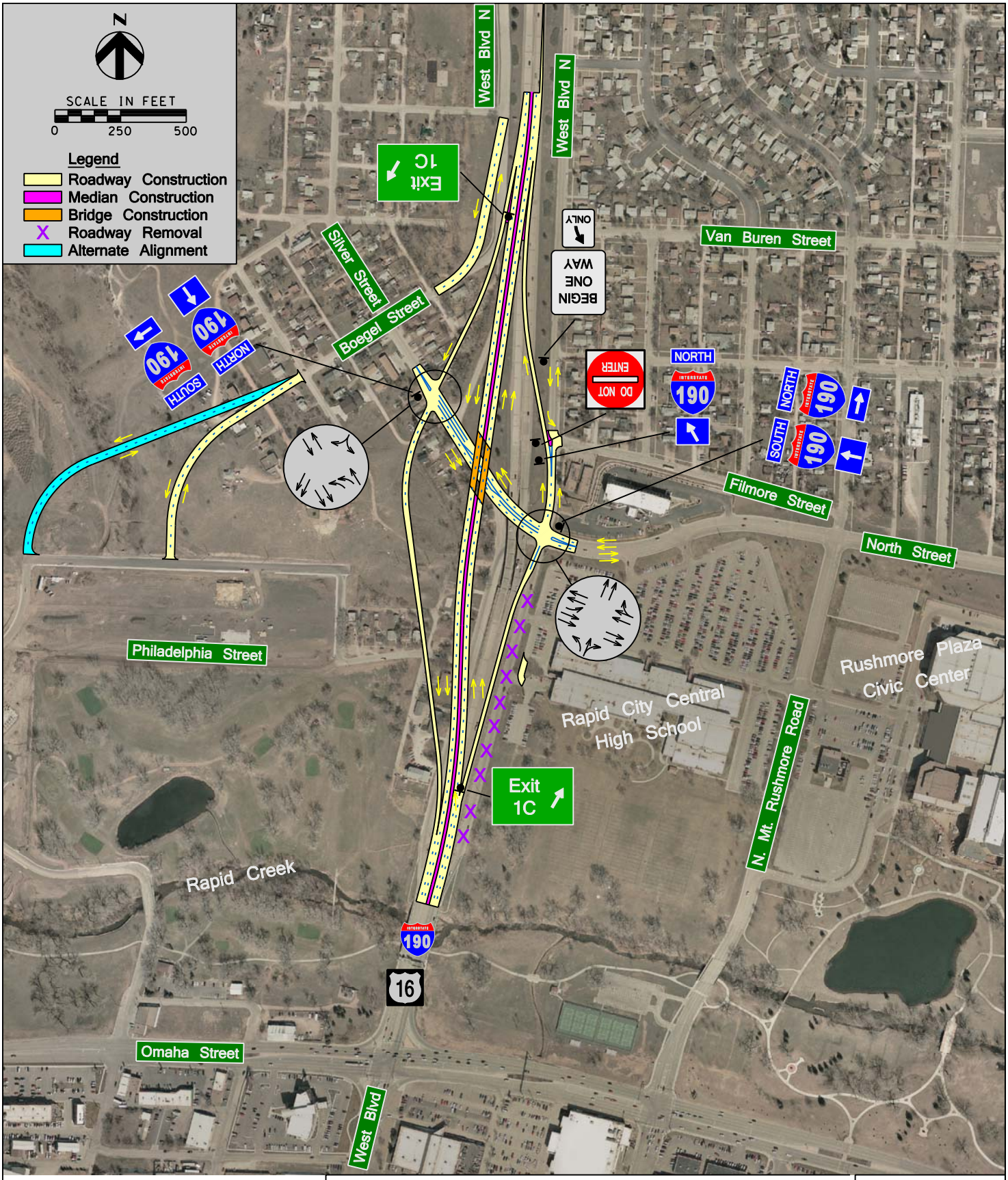
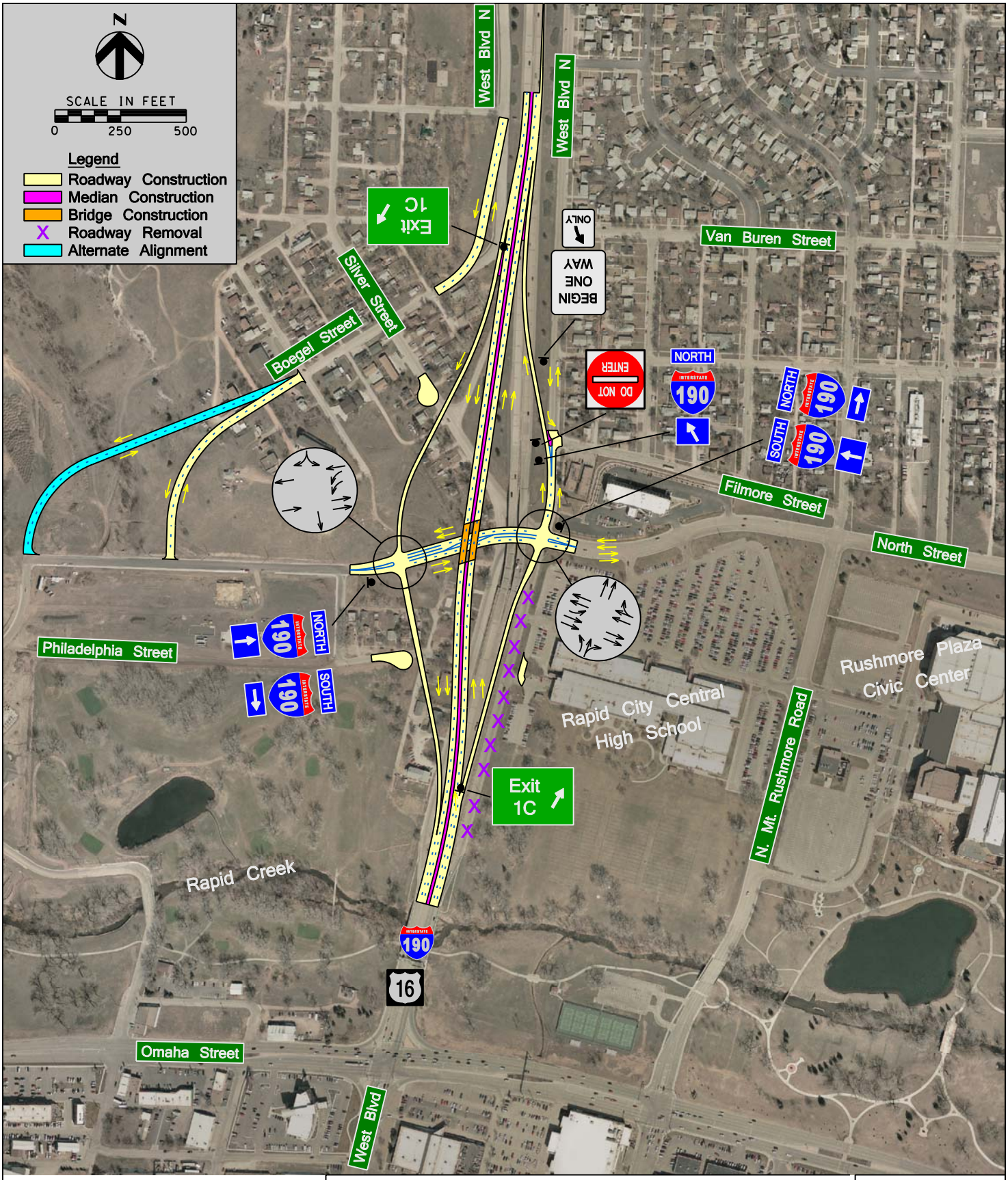


Interchange Option 1

Full Diamond Interchange at Silver Street/North Street with I-190 shifted west

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010

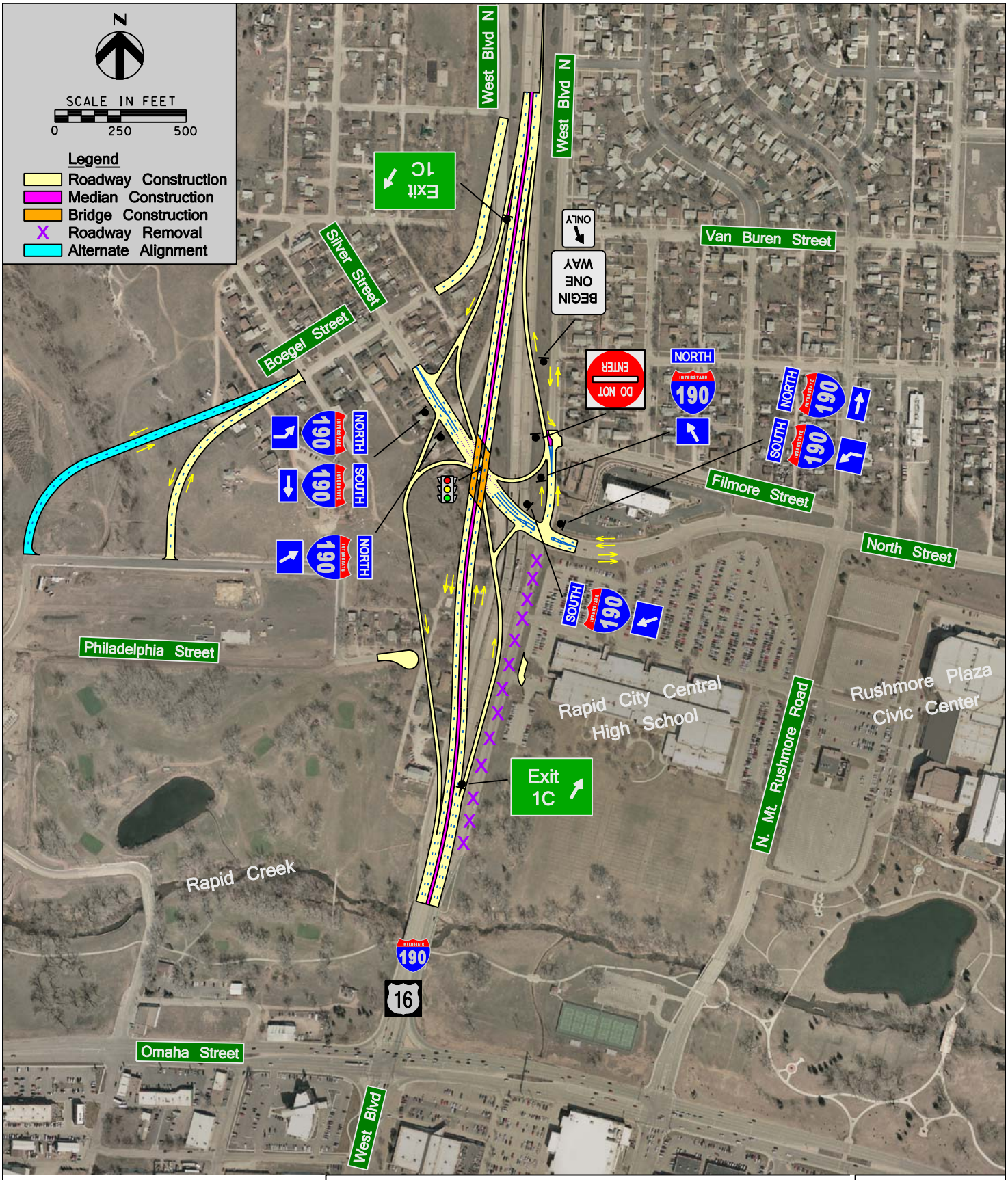


Interchange Option 1a

Full Diamond Interchange at North Street with I-190 shifted west

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010

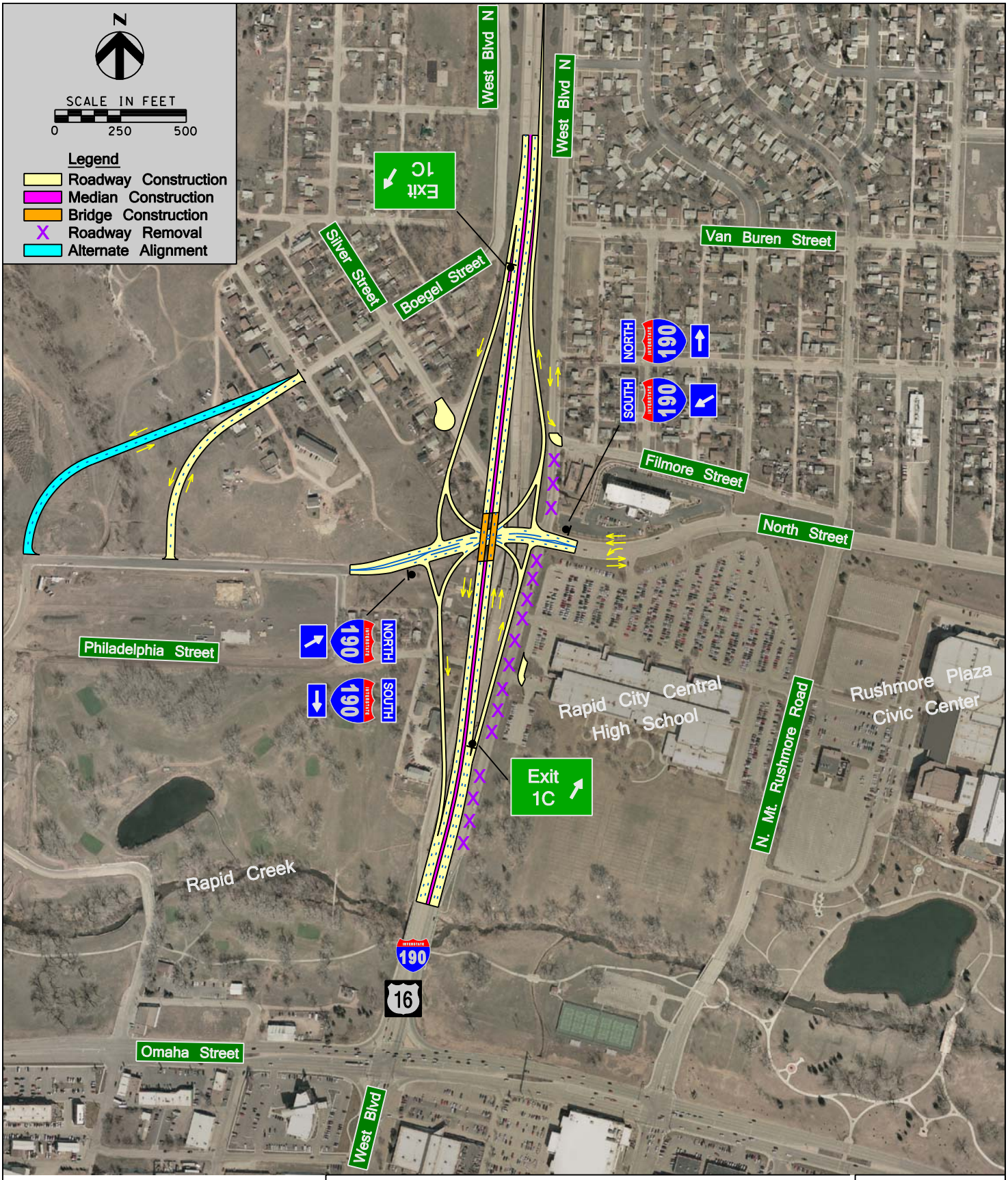


Interchange Option 2

Single Point Diamond Interchange at Silver Street with I-190 shifted west

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010

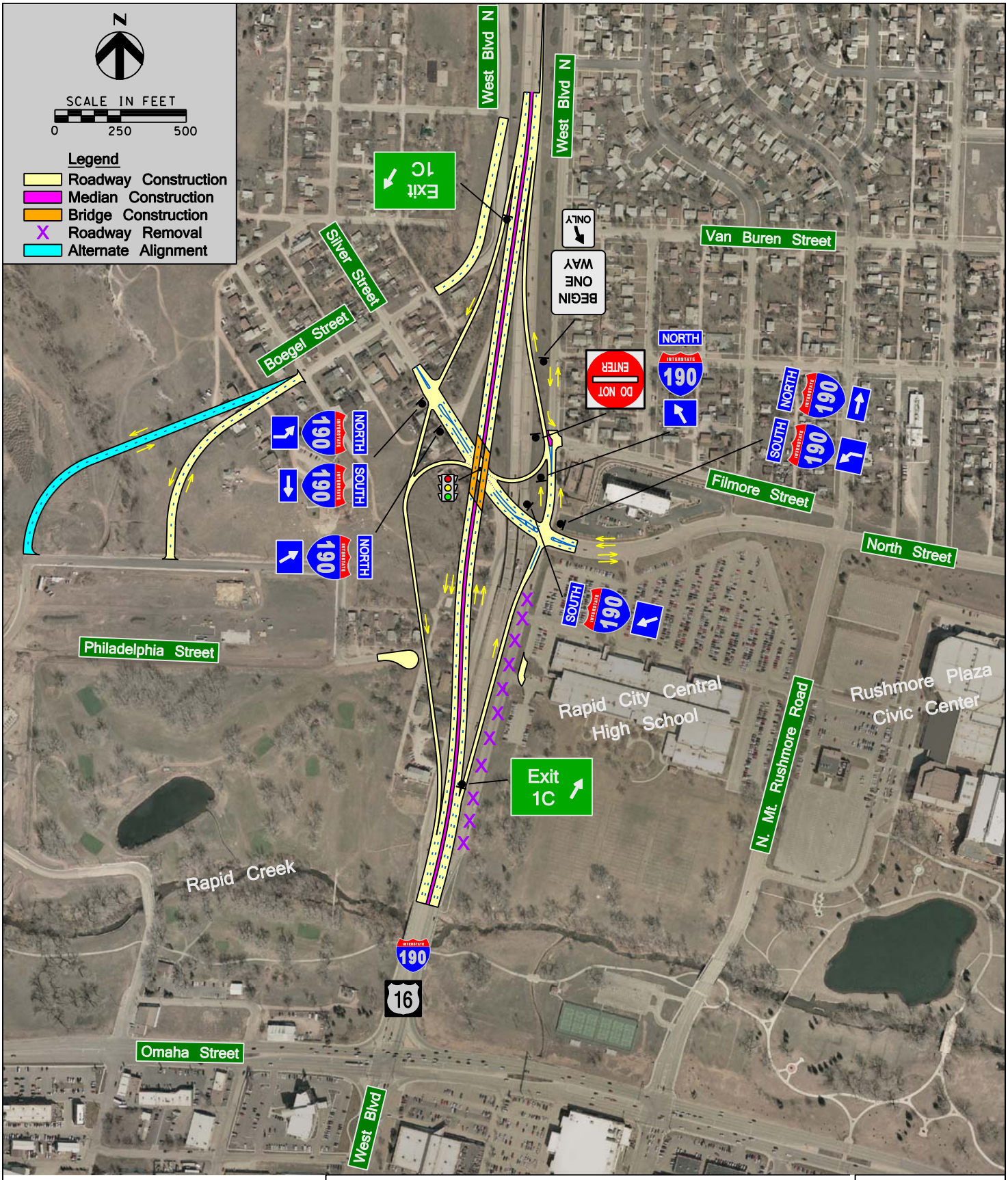


Interchange Option 2a

Single Point Diamond Interchange at North Street with I-190 shifted west

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010

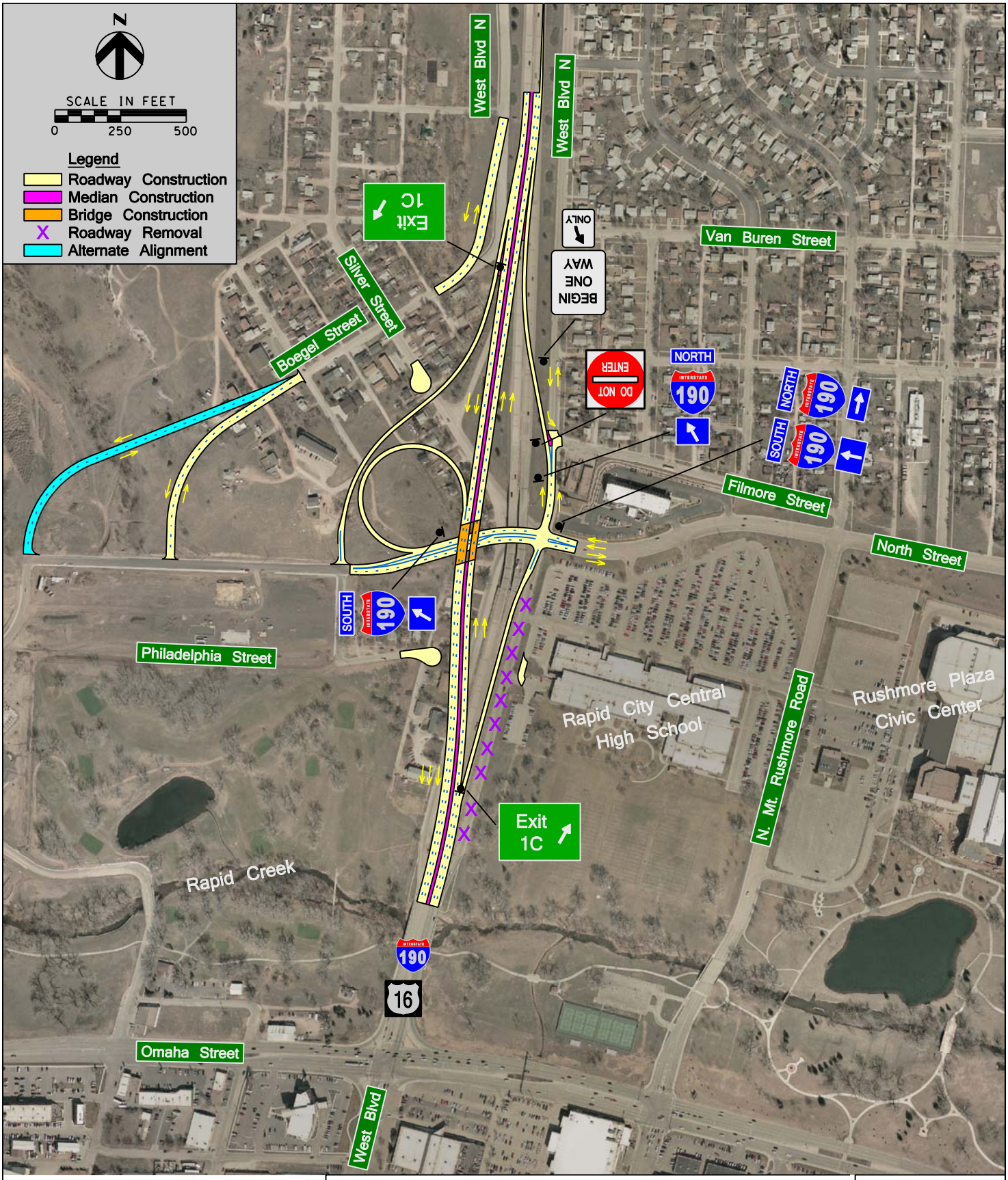


Interchange Option 2 Hybrid

Hybrid Single Point Diamond Interchange at Silver Street with I-190 shifted west

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010

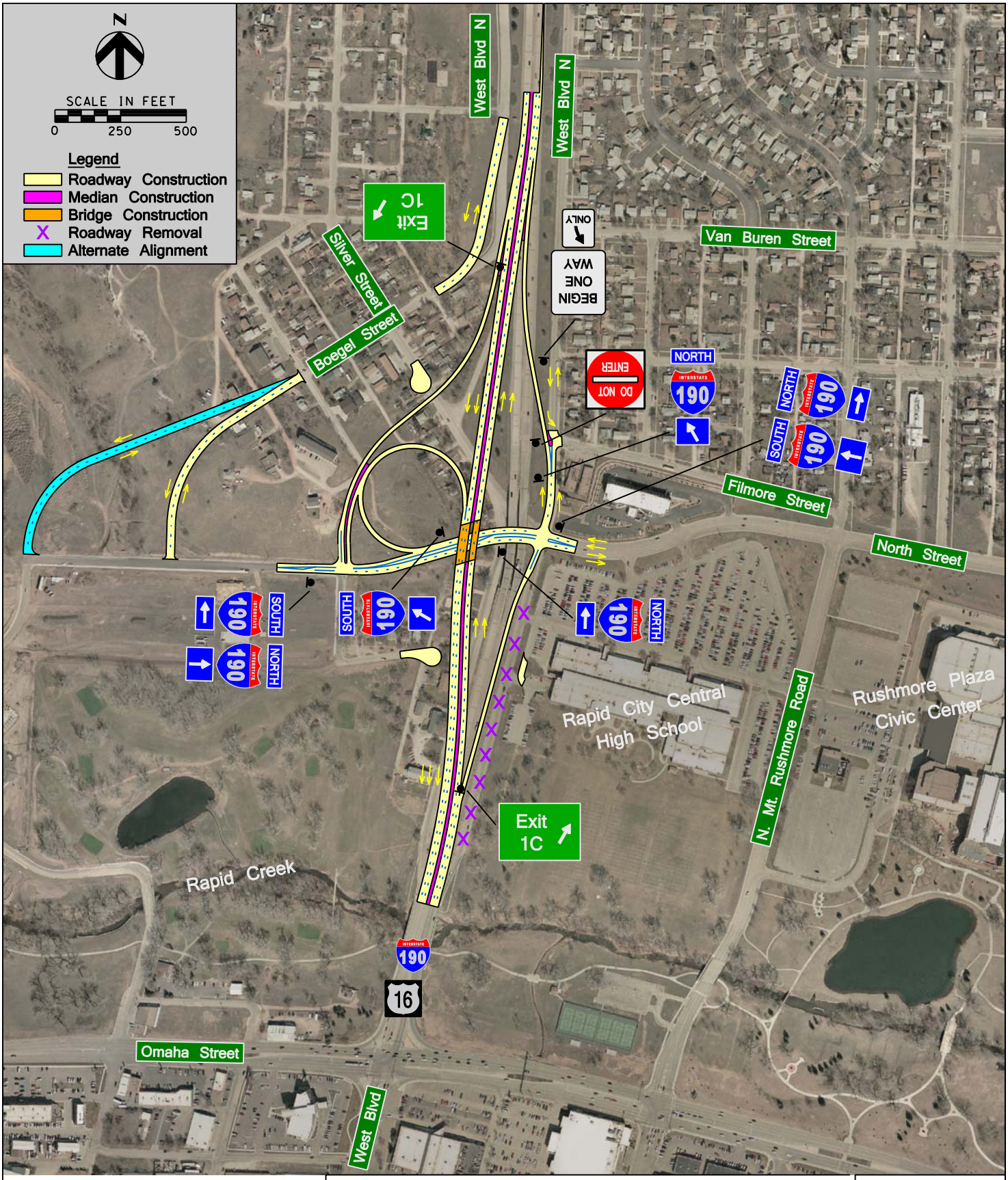


Interchange Option 3

I-190 Interchange with Loop at North Street

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010

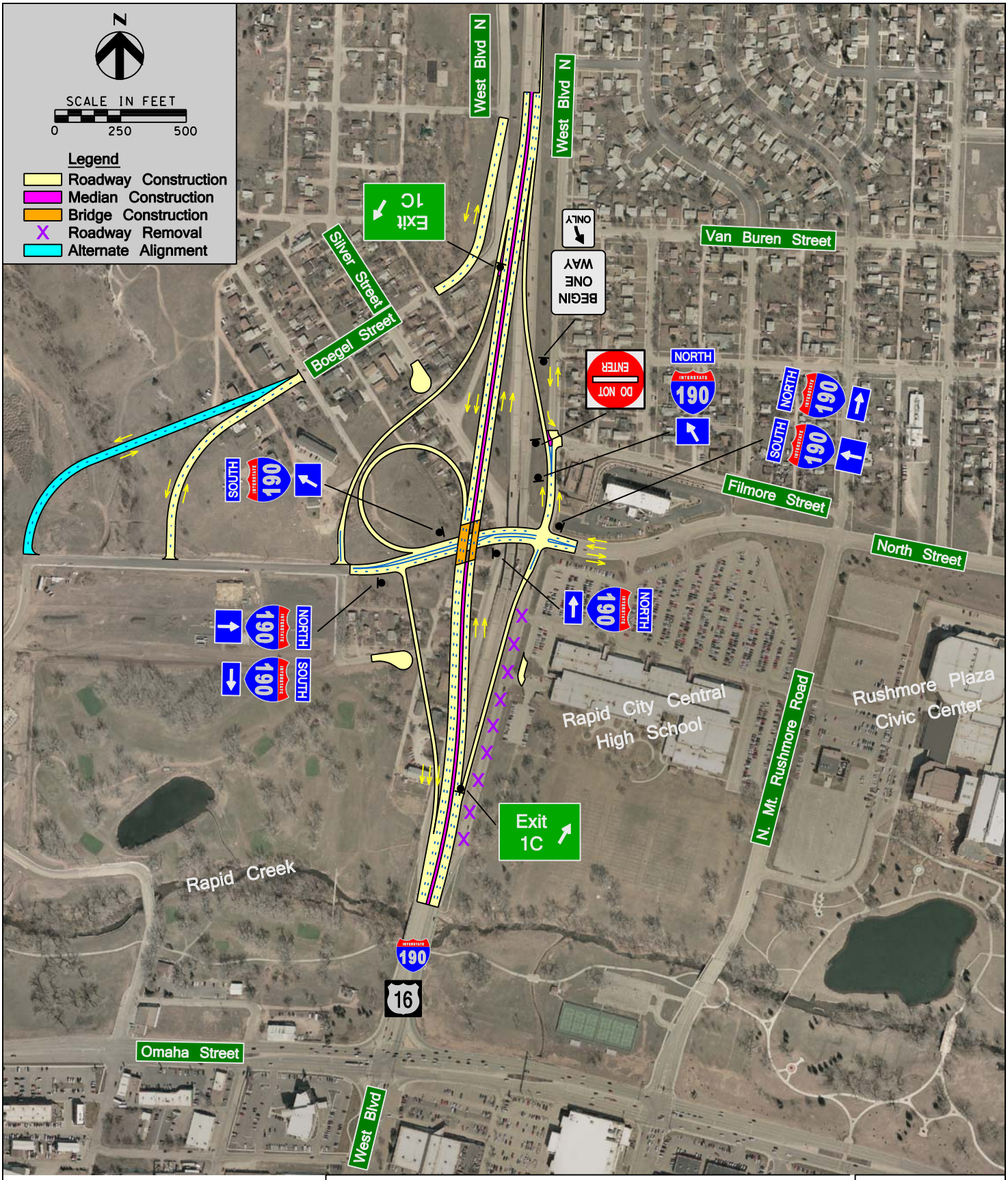


Interchange Option 3a

I-190 Interchange with Loop at North Street and EB to SB access

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010



Interchange Option 3b

I-190 Interchange with Loop at North Street and EB to SB on-ramp

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

May 27, 2010

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Meeting Notes

Subject:	Concept review meeting
Client:	SDDOT
Project:	I-190/Silver Street Study
Project No:	137390, HP 5596(12)
Meeting Date:	5/13/2010
Meeting Location:	SDDOT Central Office
Notes by:	R Laughlin

Attendees:

Steve Johnson	Bridge Design Engineer	SDDOT	605-773-3285	steve.johnson@state.sd.us
Kevin Goeden	Chief Bridge Engineer	SDDOT	605-773-3285	kevin.goeden@state.sd.us
Dean VanDeWiele	Bid Letting Supervisor	SDDOT	605-773-3938	dean.vandeweile@state.sd.us
Brad Remmich	Transportation Specialist	SDDOT	605-773-3093	bradley.remmich@state.sd.us
Dan Staton	Access Mgmt. Engineer	SDDOT	605-394-2244	daniel.staton@state.sd.us
Gary Engel	Area Engineer	SDDOT	605-394-2248	gary.engel@state.sd.us
Mark Leiferman	Road Design Engineer	SDDOT	605-773-3452	mark.leiferman@state.sd.us
Steve Gramm	Data Analysis Engineer	SDDOT	605-773-6641	steve.gramm@state.sd.us
Todd Seaman	Region Engineer	SDDOT	605-394-1620	todd.seaman@state.sd.us
Steve Hoff	Asst. Dept. Manager	HDR	605-977-7740	steve.hoff@hdrinc.com
Jody Page	RC Manager	HDR	605-791-6100	jody.page@hdrinc.com
Chris Bailey	Project Engineer	HDR	605-791-6100	chris.bailey@hdrinc.com
Rick Laughlin	Sr. Transp. Engineer	HDR	605-977-7740	rick.laughlin@hdrinc.com

Topics Discussed:

1. Study Synopsis – Laughlin provided background information and design history. Recent information was provided regarding the impending closure of the low-clearance portion of the crossroad under the Silver St. interchange.
2. Interstate improvement concepts – attendees reviewed improvement concepts for the I-190/Silver St. interchange.
    a. SDDOT's position is that I-190 will remain as a state-jurisdiction route, whether or not it remains on the Interstate system. The main intent of the study is stated as addressing the interchange, while exploring other options. SDDOT intends to retain interstate standards north of the Silver St. interchange under any option.
    b. Show the US 16 shield on all concept drawings, remove reference to SD 190.
    c. The connections from Boegel St. to the new development road near Philadelphia St. should be shown on all options where it is possible. It may also be helpful to show a greater distinction between these two alternative connections so there is no confusion that they are an either/or choice.
    d. Options 2, 2a (curved connection to Mt. Rushmore Rd.) should be considered dismissed. It is deemed infeasible due to conflicts with Central High expansion, environmental impacts and high relative cost. At the upcoming public meeting, we'll show the concept from the 2000 Interstate Corridor Study and talk about potential challenges for such a connection.
    e. Any alternatives that show a connection between Central High parking lots using the existing ramp roadway should be revised to show a direct connection solely on Central High property.
    f. Provide an Option 3 using the existing Silver St./North St. crossroad configuration for purposes of discussing the difficulties of this option. Renumber the existing Option 3 as Option 3a.
3. Intersection improvement concepts – attendees reviewed improvement concepts revising the I-190/Silver St. interchange into an at-grade intersection.
    a. Revise Options 5, 5a to show no intersection connection to West Blvd., east of I-190.
    b. Dismiss Options 6, 6a (see 2d).

c. See 2a, 2b, 2c, 2e.

d. Mention the roundabout option at the public meeting and explain that the option would require a more extensive redesign of the entire corridor than currently contemplated.

4. Interstate designation – the issue of redesignating the I-190 route was discussed and a Pro/Con list was reviewed. Provide more detail regarding multi-modal use in the reasons to redesignate.

5. Evaluation criteria – a list of possible evaluation criteria were reviewed. Criteria for compliance with planned transportation networks and development impacts will be added. The following criteria will also receive higher weight in the evaluation:

    a. Preliminary environmental impacts

    b. Overall cost and public sector cost

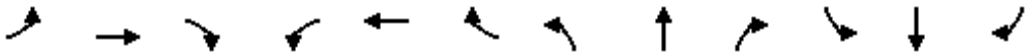
    c. Traffic operations

    d. Safety

Action/Notes:

1. HDR will revise the concepts as noted above and circulate within SDDOT at least one week prior to the public meeting.

2. HDR will continue to prepare for the public meeting and produce the technical memos.

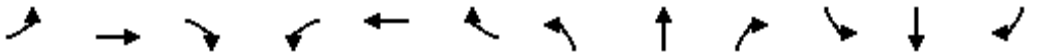


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	246	0	0	442	64	10	203	422	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor	1.00	0.95			0.95		1.00	1.00	1.00			
Frt	1.00	1.00			0.98		1.00	1.00	0.85			
Flt Protected	0.95	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (prot)	1770	3539			3472		1770	1863	1583			
Flt Permitted	0.28	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (perm)	514	3539			3472		1770	1863	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	267	0	0	480	70	11	221	459	0	0	0
RTOR Reduction (vph)	0	0	0	0	25	0	0	0	261	0	0	0
Lane Group Flow (vph)	16	267	0	0	525	0	11	221	198	0	0	0
Turn Type	pm+pt						Prot		Perm			
Protected Phases	7	4			8		5	2				
Permitted Phases	4								2			
Actuated Green, G (s)	16.1	16.1			11.5		18.3	18.3	18.3			
Effective Green, g (s)	16.1	16.1			11.5		18.3	18.3	18.3			
Actuated g/C Ratio	0.38	0.38			0.27		0.43	0.43	0.43			
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)	3.0	3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)	213	1344			942		764	804	683			
v/s Ratio Prot	0.00	c0.08			c0.15		0.01	0.12				
v/s Ratio Perm	0.03								c0.13			
v/c Ratio	0.08	0.20			0.56		0.01	0.27	0.29			
Uniform Delay, d1	8.7	8.8			13.3		6.9	7.8	7.8			
Progression Factor	1.00	1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2	0.2	0.1			0.7		0.0	0.8	1.1			
Delay (s)	8.8	8.9			14.0		6.9	8.6	8.9			
Level of Service	A	A			B		A	A	A			
Approach Delay (s)		8.9			14.0			8.8			0.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	10.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	42.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	54.1%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

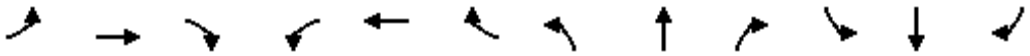
Movement	NBL	NBT	NBR	SBL	SBT	SBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations												
Volume (vph)	0	0	0	217	0	3	0	44	23	432	20	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0			4.0		4.0	4.0	
Lane Util. Factor					1.00			1.00		1.00	1.00	
Frt					1.00			0.95		1.00	1.00	
Flt Protected					0.95			1.00		0.95	1.00	
Satd. Flow (prot)					1772			1777		1770	1863	
Flt Permitted					0.95			1.00		0.95	1.00	
Satd. Flow (perm)					1772			1777		1770	1863	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	236	0	3	0	48	25	470	22	0
RTOR Reduction (vph)	0	0	0	0	1	0	0	23	0	0	0	0
Lane Group Flow (vph)	0	0	0	0	238	0	0	50	0	470	22	0
Turn Type				Perm						Prot		
Protected Phases					6			4		3	8	
Permitted Phases				6								
Actuated Green, G (s)					23.4			5.0		19.6	28.6	
Effective Green, g (s)					23.4			5.0		19.6	28.6	
Actuated g/C Ratio					0.39			0.08		0.33	0.48	
Clearance Time (s)					4.0			4.0		4.0	4.0	
Vehicle Extension (s)					3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)					691			148		578	888	
v/s Ratio Prot								c0.03		c0.27	0.01	
v/s Ratio Perm					0.13							
v/c Ratio					0.34			0.34		0.81	0.02	
Uniform Delay, d1					12.9			25.9		18.5	8.3	
Progression Factor					1.00			1.00		1.00	1.00	
Incremental Delay, d2					1.4			1.4		8.6	0.0	
Delay (s)					14.3			27.3		27.1	8.3	
Level of Service					B			C		C	A	
Approach Delay (s)		0.0			14.3			27.3			26.2	
Approach LOS		A			B			C			C	

Intersection Summary			
HCM Average Control Delay	22.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	67.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



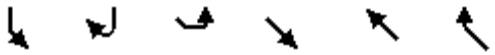
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	44	23	447	20	64	10	0	422	217	0	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	1.00	1.00		1.00	1.00		1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00		0.85	1.00		0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00
Satd. Flow (prot)	1770	3539	1583	3433	3539	1583	1770		1583	1770		1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00
Satd. Flow (perm)	1770	3539	1583	3433	3539	1583	1770		1583	1770		1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	48	25	486	22	70	11	0	459	236	0	3
RTOR Reduction (vph)	0	0	23	0	0	41	0	0	0	0	0	0
Lane Group Flow (vph)	16	48	2	486	22	29	11	0	459	236	0	3
Turn Type	Prot		Perm	Prot		Perm	Prot		Free	Prot		Free
Protected Phases	7	4		3	8		5			1		
Permitted Phases			4			8			Free			Free
Actuated Green, G (s)	0.8	3.9	3.9	17.8	20.9	20.9	16.3		50.0	16.3		50.0
Effective Green, g (s)	0.8	3.9	3.9	17.8	20.9	20.9	16.3		50.0	16.3		50.0
Actuated g/C Ratio	0.02	0.08	0.08	0.36	0.42	0.42	0.33		1.00	0.33		1.00
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0			4.0		
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0			3.0		
Lane Grp Cap (vph)	28	276	123	1222	1479	662	577		1583	577		1583
v/s Ratio Prot	0.01	0.01		c0.14	0.01		0.01			c0.13		
v/s Ratio Perm			0.00			0.02			c0.29			0.00
v/c Ratio	0.57	0.17	0.02	0.40	0.01	0.04	0.02		0.29	0.41		0.00
Uniform Delay, d1	24.4	21.5	21.3	12.1	8.5	8.6	11.4		0.0	13.1		0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00
Incremental Delay, d2	25.2	0.3	0.1	0.2	0.0	0.0	0.0		0.5	0.5		0.0
Delay (s)	49.6	21.8	21.3	12.3	8.5	8.7	11.4		0.5	13.6		0.0
Level of Service	D	C	C	B	A	A	B		A	B		A
Approach Delay (s)		26.7			11.7			0.7			13.4	
Approach LOS		C			B			A			B	

Intersection Summary			
HCM Average Control Delay	9.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	50.0	Sum of lost time (s)	4.0
Intersection Capacity Utilization	38.1%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	246	0	0	442	64	10	203	422	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor	1.00	0.95			0.95		1.00	1.00	1.00			
Frt	1.00	1.00			0.98		1.00	1.00	0.85			
Flt Protected	0.95	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (prot)	1770	3539			3472		1770	1863	1583			
Flt Permitted	0.28	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (perm)	514	3539			3472		1770	1863	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	267	0	0	480	70	11	221	459	0	0	0
RTOR Reduction (vph)	0	0	0	0	25	0	0	0	261	0	0	0
Lane Group Flow (vph)	16	267	0	0	525	0	11	221	198	0	0	0
Turn Type	pm+pt						Prot		Perm			
Protected Phases	7	4			8		5	2				
Permitted Phases	4								2			
Actuated Green, G (s)	16.1	16.1			11.5		18.3	18.3	18.3			
Effective Green, g (s)	16.1	16.1			11.5		18.3	18.3	18.3			
Actuated g/C Ratio	0.38	0.38			0.27		0.43	0.43	0.43			
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)	3.0	3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)	213	1344			942		764	804	683			
v/s Ratio Prot	0.00	c0.08			c0.15		0.01	0.12				
v/s Ratio Perm	0.03								c0.13			
v/c Ratio	0.08	0.20			0.56		0.01	0.27	0.29			
Uniform Delay, d1	8.7	8.8			13.3		6.9	7.8	7.8			
Progression Factor	1.00	1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2	0.2	0.1			0.7		0.0	0.8	1.1			
Delay (s)	8.8	8.9			14.0		6.9	8.6	8.9			
Level of Service	A	A			B		A	A	A			
Approach Delay (s)		8.9			14.0			8.8			0.0	
Approach LOS		A			B			A			A	

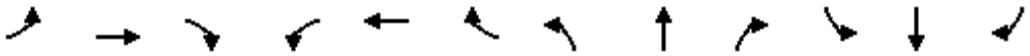
Intersection Summary			
HCM Average Control Delay	10.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	42.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	53.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	SBL	SBR	SEL	SET	NWT	NWR
Lane Configurations						
Sign Control	Stop			Stop	Stop	
Volume (vph)	217	3	0	67	20	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	236	3	0	73	22	0

Direction, Lane #	SB 1	SE 1	NW 1
Volume Total (vph)	239	73	22
Volume Left (vph)	0	0	22
Volume Right (vph)	3	73	0
Hadj (s)	0.03	-0.57	0.23
Departure Headway (s)	4.1	3.9	4.5
Degree Utilization, x	0.27	0.08	0.03
Capacity (veh/h)	862	865	766
Control Delay (s)	8.6	7.2	7.7
Approach Delay (s)	8.6	7.2	7.7
Approach LOS	A	A	A

Intersection Summary			
Delay	8.3		
HCM Level of Service	A		
Intersection Capacity Utilization	67.2%	ICU Level of Service	C
Analysis Period (min)	15		

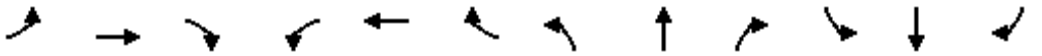


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	88	0	0	407	39	10	160	157	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor	1.00	0.95			0.95		1.00	1.00	1.00			
Frt	1.00	1.00			0.99		1.00	1.00	0.85			
Flt Protected	0.95	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (prot)	1770	3539			3493		1770	1863	1583			
Flt Permitted	0.31	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (perm)	580	3539			3493		1770	1863	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	96	0	0	442	42	11	174	171	0	0	0
RTOR Reduction (vph)	0	0	0	0	16	0	0	0	96	0	0	0
Lane Group Flow (vph)	12	96	0	0	468	0	11	174	75	0	0	0
Turn Type	pm+pt						Prot		Perm			
Protected Phases	7	4			8		5	2				
Permitted Phases	4								2			
Actuated Green, G (s)	15.4	15.4			10.8		18.4	18.4	18.4			
Effective Green, g (s)	15.4	15.4			10.8		18.4	18.4	18.4			
Actuated g/C Ratio	0.37	0.37			0.26		0.44	0.44	0.44			
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)	3.0	3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)	231	1304			902		779	820	697			
v/s Ratio Prot	0.00	c0.03			c0.13		0.01	c0.09				
v/s Ratio Perm	0.02								0.05			
v/c Ratio	0.05	0.07			0.52		0.01	0.21	0.11			
Uniform Delay, d1	8.7	8.6			13.3		6.6	7.2	6.9			
Progression Factor	1.00	1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2	0.1	0.0			0.5		0.0	0.6	0.3			
Delay (s)	8.8	8.6			13.8		6.6	7.8	7.2			
Level of Service	A	A			B		A	A	A			
Approach Delay (s)		8.6			13.8			7.5			0.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	10.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	41.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	40.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

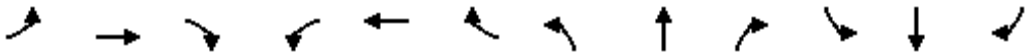
Movement	NBL	NBT	NBR	SBL	SBT	SBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations												
Volume (vph)	0	0	0	67	0	3	0	66	30	380	33	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0			4.0		4.0	4.0	
Lane Util. Factor					1.00			1.00		1.00	1.00	
Frt					0.99			0.96		1.00	1.00	
Flt Protected					0.95			1.00		0.95	1.00	
Satd. Flow (prot)					1768			1784		1770	1863	
Flt Permitted					0.95			1.00		0.69	1.00	
Satd. Flow (perm)					1768			1784		1284	1863	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	73	0	3	0	72	33	413	36	0
RTOR Reduction (vph)	0	0	0	0	2	0	0	19	0	0	0	0
Lane Group Flow (vph)	0	0	0	0	74	0	0	86	0	413	36	0
Turn Type				Perm						Perm		
Protected Phases					6			4			8	
Permitted Phases				6						8		
Actuated Green, G (s)					21.0			21.0		21.0	21.0	
Effective Green, g (s)					21.0			21.0		21.0	21.0	
Actuated g/C Ratio					0.42			0.42		0.42	0.42	
Clearance Time (s)					4.0			4.0		4.0	4.0	
Vehicle Extension (s)					3.0			3.0		3.0	3.0	
Lane Grp Cap (vph)					743			749		539	782	
v/s Ratio Prot								0.05			0.02	
v/s Ratio Perm					0.04					c0.32		
v/c Ratio					0.10			0.11		0.77	0.05	
Uniform Delay, d1					8.8			8.8		12.4	8.6	
Progression Factor					1.00			1.00		1.00	1.00	
Incremental Delay, d2					0.3			0.1		6.4	0.0	
Delay (s)					9.0			8.9		18.8	8.6	
Level of Service					A			A		B	A	
Approach Delay (s)		0.0			9.0			8.9			18.0	
Approach LOS		A			A			A			B	

Intersection Summary			
HCM Average Control Delay	15.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	50.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	40.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



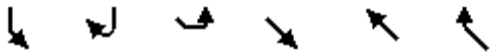
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	66	30	380	33	39	10	0	317	67	0	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	1.00	1.00		1.00	1.00		1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00		0.85	1.00		0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00
Satd. Flow (prot)	1770	3539	1583	3433	3539	1583	1770		1583	1770		1583
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95		1.00	0.95		1.00
Satd. Flow (perm)	1770	3539	1583	3433	3539	1583	1770		1583	1770		1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	72	33	413	36	42	11	0	345	73	0	3
RTOR Reduction (vph)	0	0	27	0	0	23	0	0	0	0	0	0
Lane Group Flow (vph)	12	72	6	413	36	19	11	0	345	73	0	3
Turn Type	Prot		Perm	Prot		Perm	Prot		Free	Prot		Free
Protected Phases	7	4		3	8		5			1		
Permitted Phases			4			8			Free			Free
Actuated Green, G (s)	0.8	7.1	7.1	12.1	18.4	18.4	8.8		40.0	8.8		40.0
Effective Green, g (s)	0.8	7.1	7.1	12.1	18.4	18.4	8.8		40.0	8.8		40.0
Actuated g/C Ratio	0.02	0.18	0.18	0.30	0.46	0.46	0.22		1.00	0.22		1.00
Clearance Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0			4.0		
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0			3.0		
Lane Grp Cap (vph)	35	628	281	1038	1628	728	389		1583	389		1583
v/s Ratio Prot	0.01	0.02		c0.12	0.01		0.01			0.04		
v/s Ratio Perm			0.00			0.01			c0.22			0.00
v/c Ratio	0.34	0.11	0.02	0.40	0.02	0.03	0.03		0.22	0.19		0.00
Uniform Delay, d1	19.3	13.8	13.6	11.1	5.9	5.9	12.2		0.0	12.7		0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00
Incremental Delay, d2	5.8	0.1	0.0	0.3	0.0	0.0	0.0		0.3	0.2		0.0
Delay (s)	25.1	13.9	13.6	11.3	5.9	5.9	12.3		0.3	12.9		0.0
Level of Service	C	B	B	B	A	A	B		A	B		A
Approach Delay (s)		15.0			10.5			0.7			12.4	
Approach LOS		B			B			A			B	

Intersection Summary			
HCM Average Control Delay	7.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.25		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	0.0
Intersection Capacity Utilization	27.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	11	88	0	0	407	39	10	160	157	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Lane Util. Factor	1.00	0.95			0.95		1.00	1.00	1.00			
Frt	1.00	1.00			0.99		1.00	1.00	0.85			
Flt Protected	0.95	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (prot)	1770	3539			3493		1770	1863	1583			
Flt Permitted	0.31	1.00			1.00		0.95	1.00	1.00			
Satd. Flow (perm)	580	3539			3493		1770	1863	1583			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	96	0	0	442	42	11	174	171	0	0	0
RTOR Reduction (vph)	0	0	0	0	16	0	0	0	96	0	0	0
Lane Group Flow (vph)	12	96	0	0	468	0	11	174	75	0	0	0
Turn Type	pm+pt						Prot		Perm			
Protected Phases	7	4			8		5	2				
Permitted Phases	4								2			
Actuated Green, G (s)	15.4	15.4			10.8		18.4	18.4	18.4			
Effective Green, g (s)	15.4	15.4			10.8		18.4	18.4	18.4			
Actuated g/C Ratio	0.37	0.37			0.26		0.44	0.44	0.44			
Clearance Time (s)	4.0	4.0			4.0		4.0	4.0	4.0			
Vehicle Extension (s)	3.0	3.0			3.0		3.0	3.0	3.0			
Lane Grp Cap (vph)	231	1304			902		779	820	697			
v/s Ratio Prot	0.00	c0.03			c0.13		0.01	c0.09				
v/s Ratio Perm	0.02								0.05			
v/c Ratio	0.05	0.07			0.52		0.01	0.21	0.11			
Uniform Delay, d1	8.7	8.6			13.3		6.6	7.2	6.9			
Progression Factor	1.00	1.00			1.00		1.00	1.00	1.00			
Incremental Delay, d2	0.1	0.0			0.5		0.0	0.6	0.3			
Delay (s)	8.8	8.6			13.8		6.6	7.8	7.2			
Level of Service	A	A			B		A	A	A			
Approach Delay (s)		8.6			13.8			7.5			0.0	
Approach LOS		A			B			A			A	

Intersection Summary			
HCM Average Control Delay	10.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.32		
Actuated Cycle Length (s)	41.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	34.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	SBL	SBR	SEL	SET	NWT	NWR
Lane Configurations						
Sign Control	Stop			Stop	Stop	
Volume (vph)	67	3	0	96	33	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	73	3	0	104	36	0

Direction, Lane #	SB 1	SE 1	NW 1
Volume Total (vph)	76	104	36
Volume Left (vph)	0	0	36
Volume Right (vph)	3	104	0
Hadj (s)	0.01	-0.57	0.23
Departure Headway (s)	4.1	3.6	4.4
Degree Utilization, x	0.09	0.10	0.04
Capacity (veh/h)	843	972	785
Control Delay (s)	7.5	7.0	7.6
Approach Delay (s)	7.5	7.0	7.6
Approach LOS	A	A	A

Intersection Summary			
Delay	7.3		
HCM Level of Service	A		
Intersection Capacity Utilization	34.2%	ICU Level of Service	A
Analysis Period (min)	15		